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HOW AND WHY FATALITIES OCCURRED IN PENNSYLVANIA BITUMINOUS COAL MINES DURING THE FIVE-YEAR PERIOD, 1926-1930

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HOW AND WHY FATALITIES OCCURRED IN PENNSYLVANIA BITUMINOUS COAL MINES DURING THE FIVE-YEAR PERIOD, 1926 - 1930[1]

By W. J. Fene[2]

PURPOSE OF REPORT

A comprehensive study of all bituminous coal-mine fatalities occurring in Pennsylvania during the 5-year period, 1926-1930, was made to try to determine the factors that influence accidents which cause these fatalities. During this study some two thousand reports of fatalities were reviewed, and pertinent information as to causes and influencing factors were tabulated therefrom. These tabulations are discussed in detail, and in some instances recommendations are made with a view to reducing the hazards in certain classes of these accidents.

ACKNOWLEDGMENT

This study was made possible through the cooperation of Walter H. Glasgow, secretary of mines, Pennsylvania Department of Mines, who made available its records and extended every assistance and courtesy during this study.

SCOPE OF STUDY

The fatality reports studied cover the years 1926 to 1930, inclusive, and include 1,982 fatalities from all causes. This study covers all fatalities occurring in and around the mines, including those in mines employing fewer than ten men; this class is not required by law to report accidents, and the reports that are obtained are those that come to the attention of the district inspectors.

Nonfatal accidents have not been considered in this study other than to enumerate the number occurring in connection with compensation awards.

Fatal accidents have been classified as to causes, place in mine where accident occurred, nationality of those killed, age, occupation, years of experience, and time of day.

The factors which influence conditions that are likely to bring about fatalities from falls of roof and coal and also economic losses due to fatalities and injuries are classified and discussed.

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1 The Bureau of Mines will welcome the reprinting of this paper, provided the following footnote acknowledgment is used: "Reprinted from U. S. Bureau of Mines Information Circular 6505."

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PENNSYLVANIA FATALITY RATES

The fatality rates for the bituminous-coal mines of Pennsylvania are lower than the average for the United States, although the natural conditions in many of the mines are as unfavorable as are likely to be found elsewhere. In the Pittsburgh coal bed, from which the greater part of the State's production is obtained, a treacherous draw slate occurs over the coal and is responsible for most of the fatalities from falls of roof.

In the compilation of the statistical tables used in this report, data were collected from the records of the Pennsylvania Department of Mines and from United States Bureau of Mines publications. In many cases the records of the two sources do not agree, chiefly because the Bureau of Mines records include those fatalities that occur in small mines which do not come under the State regulations and are not included in the records of the State Department of Mines.

In considering the fatality rates, consideration must be given to numerous factors, such as time involved, number of men in the mine, and production. Unquestionably, the fairest method of comparison of accidents is based on the fatalities of other accidents per million man-hours worked, which gives the rate per time of exposure in and around the mines. However, men work a varying number of hours in the mines, and it is difficult to procure exact figures as to the number of hours worked — in fact, exact figures on man-hours of exposure are very seldom available in mining. The most readily available basis for figuring accidents on an approximate time of exposure is of 300 working days. Another basis for comparison of accidents is that of production per accident; when considered alone, this is merely a cost figure, as many factors enter into large or small production of coal per man. In mines that use the same mining methods and work the same coal bed under similar natural conditions, a comparison of rates on a tonnage basis would have a definite relative meaning; otherwise a comparison on this basis may mean little, or be unfair.

Table 1 is a comparison of Pennsylvania fatality rates with those of the United States as a whole for a period of 20 years. It is noted that the average yearly number killed in Pennsylvania bituminous-coal mines is 421, and the average of the United States is 2,344.

In this 20-year period, Pennsylvania produced 25.7 per cent of the bituminous coal in the United States, while the State was responsible for 18 per cent of the fatalities which occurred during this period.

There was a marked reduction in the number of fatalities during 1930; there were 300 killed as against the average of 421 for the 20-year period. The small number of fatalities for 1930 is the best for the past 30 years, with the exception of 1921 when production was below normal. The fatalities during the years 1911, 1913, and 1928 were considerably above the average, due to disastrous explosions occurring during these years. There has not been a major explosion (one in which five or more were killed) in Pennsylvania bituminous coal mines from March, 1929, to July, 1931.

The death rate per million tons of bituminous coal mined in Pennsylvania has not exceeded that of the United States, except in 1928, in which year one explosion cost the lives of 194 men. The average deaths per million tons of coal mined for Pennsylvania for the 20-year period was 2.87, as compared to 4.09 for the United States. The average number of

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tons of coal per fatality of Pennsylvania was 356,403 tons compared with 247,497 tons per fatality for the United States for the 20-year period 1911 - 1930.

In comparing the fatality rate on the basis of a thousand 300-day workers, it is seen that Pennsylvania's rate for 1928 was higher than that for the United States. However, the State's average rate on this basis for the 20-year period is approximately 26 per cent less than that for the United States, being 3.30 for Pennsylvania as compared with 4.45 for the United States for a 19-year period, the data for 1930 not being available for the United States.

Table 1.- Comparison of Pennsylvania (bituminous mines) fatality rates with that of the United States as a whole, 1911 - 1930, inclusive[1]

Year	Number killed		Deaths per million tons		Tons per fatality		Deaths per 1000 300-day workers	
	Pa.	U. S.	Pa.	U. S.	Pa.	U. S.	Pa.	U. S.
1911	515	2,656	3.62	5.35	276,096	186,887	3.63	4.97
1912	446	2,419	2.77	4.53	360,606	220,945	2.91	4.46
1913	611	2,785	3.53	4.89	283,086	204,685	3.61	4.70
1914	413	2,454	2.83	4.78	353,231	209,261	2.95	4.66
1915	442	2,269	2.81	4.27	356,154	234,297	3.12	4.44
1916	436	2,226	2.58	3.77	387,899	265,094	2.90	3.93
1917	494	2,696	2.89	4.14	346,304	241,618	3.04	4.25
1918	494	2,580	2.79	3.80	358,739	262,873	3.03	3.94
1919	401	2,323	2.73	4.19	366,797	238,464	3.05	4.28
1920	424	2,272	2.54	3.45	393,700	289,729	2.90	3.78
1921	284	1,995	2.48	3.94	402,983	253,832	2.82	4.20
1922	424	1,984	3.91	4.16	255,488	240,399	4.24	4.90
1923	401	2,462	2.37	3.74	421,898	267,223	2.82	4.39
1924	345	2,402	2.68	4.20	373,191	237,974	3.30	4.80
1925	312	2,234	2.31	3.84	433,547	260,461	2.83	4.65
1926	426	2,518	2.81	3.83	356,212	261,241	3.46	4.50
1927	356	2,231	2.70	3.73	369,789	267,978	3.33	4.43
1928	513	2,176	3.95	3.78	253,111	264,749	5.12	4.64
1929	387	2,187	2.72	3.59	367,832	278,380	3.69	4.54
1930	300	2,014	2.43	3.79	411,393	263,869	3.28[2]	-
Total	8,424	46,883	57.45	81.77	7,128,056	4,949,959	66.03	84.46
Average	421	2,344	2.87	4.09	356,403	247,497	3.30	4.45

1 Data of Pennsylvania rates from records of State Department of Mines, Data of United States rates from U. S. Bureau of Mines bulletins.

2 Estimated.

CAUSES OF ACCIDENTS

Table 2 shows the number of fatalities by causes that have occurred during the 5-year period, 1926 - 1930. As is the case in the United States as a whole, the greatest percentage of fatalities was due to falls of roof and coal, 53.08 per cent of all fatalities being ascribed to this cause; gas and dust explosions were responsible for 18.06 per cent, and haulage for 15.49 per cent of those killed underground. During the 5-year period,

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fatalities caused by mining machines showed a gradual increase, much of which may be charged to the increased use of these machines.

Table 2.- Number of fatalities by causes, Pennsylvania bituminous mines, 1926 - 1930[1]

Cause of accident	1926	1927	1928	1929	1930	Total	Per cent of total
Killed underground:							
Falls of roof and coal	241	215	170	226	200	1,052	53.08
Haulage	65	63	67	62	50	307	15.49
Gas and dust explosions	69	10	227	47	5	358	18.06
Explosives	9	12	4	9	8	42	2.12
Suffocation from mine gases	-	-	1	3	-	4	0.20
Electricity	8	15	12	7	8	50	2.52
Mining machines	4	7	7	8	11	37	1.87
Shaft accidents	3	-	4	3	2	12	0.60
Other causes	7	10	6	6	5	34	1.72
Total	406	332	498	371	289	1,896	95.66
Killed outside of mine:							
Haulage	8	12	7	10	6	43	2.17
Electricity	3	3	2	2	-	10	0.50
Machinery	9	1	1	1	1	13	0.66
Other causes	-	8	5	3	4	20	1.01
Total	20	24	15	16	11	86	4.34
Grand total	426	356	513	387	300	1,982	100.00

1 Data obtained from records of Pennsylvania Department of Mines.

OCCUPATIONS OF THOSE KILLED

Tagle 3 shows the occupations of those killed and the percentage of the number employed, excluding those killed by explosions. This table gives an indication of the relative hazards of the different occupations, both underground and on the surface.

It appears that rockmen and timbermen have by far the most hazardous occupations underground, 0.527 per cent of those thus employed being killed yearly. Of the 80 rockmen and timbermen killed during the 5-year period, 68 were killed by falls of roof and coal. As a rule, men employed in these occupations are those who have had considerable underground experience, and the large death rate in this line of mining activity might indicate that they are not properly supervised and disciplined, and that they may be careless in performing their duties.

Next to those engaged as rockmen and timbermen, machinemen and helpers suffer a greater loss than any other class of underground workers. About 58 per cent of the machinemen killed during the 5-year period met death by falls of roof and coal, and 11 per cent in connection with transportation of the machines. The high percentage killed by falls of roof and coal may have been due to at least four factors: (1) In many cases it was necessary to

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remove a post to make room for the machine; (2) the noise made by the machine did not permit the operators to hear the "working" of the roof; (3) the vibration of the machine on the coal and on the roof loosened the material to the extent that it fell; (4) the machine took so much space in its manipulation that enough props could not be placed.

Haulage employees rank third in death rate. Of the group engaged in haulage, the occupation of motorman's assistant, sometimes called brakeman or trip rider, is the most hazardous.

The death rate of underground officials is fairly large; it is difficult to explain the reason for this, as mine officials are supposed to be men who have had considerable experience and who know the dangerous conditions when they are encountered and how to handle these dangers safely. Of the 28 officials killed during the 5-year period, 12 were killed by falls of roof or coal, and 8 by haulage. Six of those killed by haulage were fire bosses, indicating a very bad practice in which fire bosses use locomotives during their inspections. The percentage of officials killed yearly on the surface is by far greater than in any other outside occupation. It is universally agreed that the idea of safety and the prevention of accidents should emanate from the officials; if this is true, then it appears from this record that officials are setting a bad example in not using the proper precautions to protect themselves.

While more machine and pick miners are killed than workers in any other occupation, the number employed is far greater than in any other occupation. The percentage of machine miners killed yearly compared with the total engaged in that occupation during the 5-year period was 0.228, and of pick miners, 0.218, from which figures it would appear that the relative hazard of the two methods of mining is slightly in favor of the pick miners.

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Tagle 3.- Occupations of those killed and per cent of number employed, 1926 - 1930, Pennsylvania bituminous mines
(Exclusive of those killed by explosions)

Occupation	1926	1927	1928	1929	1930	Total	Employed yearly, average	Killed yearly, per cent
Underground								
Rockman and timberman	13	18	9	19	21	80	3,033	0.527
Machineman and helper	14	26	18	22	28	108	6,616	0.326
Motorman	8	11	8	6	15	48	3,376	0.284
Motorman's assistant	11	12	13	15	10	61	2,576	0.474
Driver	16	16	7	12	12	63	4,666	0.270
Car handler	3	3	5	-	1	12	889	0.270
Rope rider	3	-	1	-	2	6	856	0.140
Total haulage								0.307
Machine miner	141	147	118	137	122	665	58,353	0.228
Pick miner	94	65	66	85	50	360	33,067	0.218
Cager	1	-	2	-	1	4)		
Driller	2	-	-	2	-	4)		
Laborer	5	6	8	4	3	26)		
Machinist	1	2	2	-	1	6)	5,415	0.196
Mason	1	1	-	-	1	3)		
Roadman	2	-	2	1	-	5)		
Rock-duster	1	-	-	-	1	2)		
Machine loader	-	-	-	-	3	3)		
Mine foreman	2	1	1	2	1	7	1,471	0.095
Assistant mine foreman	4	1	1	2	2	10	1,197	0.167
Fire goss	2	3	2	2	2	11	856	0.257
Total officials								0.159
Electrician	1	1	1	4	1	8	1,035	0.154
Shot firer	3	1	1	1	1	7	956	0.146
Trackman	7	6	8	4	5	30	4,509	0.133
Pumper and pipeman	1	2	-	4	3	10	1,644	0.122
Bratticeman	1	-	-	2	-	3	810	0.074
On Surface								
Superintendent and foreman	3	1	2	1	1	8	477	0.335
Brakeman	1	-	-	-	-	1)		
Car trimmer	1	1	-	-	-	2)		
Laborer	5	2	5	-	1	13)		
Electrician	1	2	-	-	-	3)	11,664	0.103
Locomotive engineer	1	-	-	-	-	1)		
Motorman	1	2	1	1	-	5)		
Miner	1	-	-	2	1	4)		
Slate picker	3	1	2	-	-	6)		
Others	-	10	-	11	4	25)		
Coke employee	1	2	2	-	-	5	2,869	0.035
Carpenter	1	-	-	1	-	2	1,406	0.028
Tippleman	1	3	1	-	2	7	5,905	0.024
Total	357	346	286	340	295	1,624	153,646	0.211

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AGE AND EXPERIENCE OF THOSE KILLED

During the study of the records of more than 1,600 individual fatalities in Pennsylvania during the past five years, the age and experience of each victim was tabulated, and it was found that the average age of those killed during this period was 39 years and the average experience in mines was 15.5 years. This would indicate that mine fatalities are not, in general, due to lack of experience on the part of the victim, but to carelessness, lack of supervision, discipline, or some other deficient essential.

Lack of experience and supervision was, no doubt, responsible for many of the fatalities. Seventy-nine, or nearly 5 per cent, of those killed were under the age of 20 years, and 58, or about 3½ per cent, had less than one year's experience in mining.

Of those killed during the 5-year period, 338, or 20.8 per cent were over 50 years of age, a number of whom had as much as 50 years' experience. The high death rate of the older men may be accounted for by (1) lack of agility in escaping from dangerous situations; (2) defective vision, being unable to perceive dangerous conditions in time to avoid them; (3) defective hearing, unable to hear warning given by working roof; and (4) obstinacy in not carrying out instructions, verbal or written.

There may be some excuse for deaths among inexperienced men, but the fact that the average experience of those killed was 15.5 years clearly indicates that incorrect methods of mining, training, or supervision, or possibly all of these, are being pursued, or lack of regard for danger and carelessness has been shown by the victims.

NATIONALITY OF THOSE KILLED

Table 4 shows the nationality of those killed during the 5-year period, 1926 to 1930, classified according to the average yearly number employed, number killed, and percentage killed. The experience during these five years indicates that the Irish and Horwats are the safest workers, with the Granish, Serbians, and Norwegians accounting for the highest average yearly percentage killed.

There are by far a larger number of Americans, including negroes, than of any other nationality employed in the bituminous-coal mines of Pennsylvania. No doubt a great many of those classified as Americans are men of foreign birth who have become naturalized citizens of the United States.

Four nationalities, including American, Italian, Slavonian, and Polish, represent approximately 76 per cent of all those employed in the bituminous-coal mines of Pennsylvania.

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Table 4.- Nationality of those killed during the period 1926 - 1930
(Exclusive of those killed by explosions)

Nationality	Average yearly		Percentage
	Number employed	Number killed	killed yearly
Irish	1,093	0.6	0.055
Horwat	1,843	1.6	0.087
Greek	364	0.6	0.165
Italian	14,856	25.4	0.171
Swedish	772	1.4	0.181
American	76,304	153.5	0.201
English	2,086	4.2	0.201
Hungarian	5,949	12.2	0.205
Belgian	463	1.0	0.216
German	2,022	4.4	0.217
Polish	12,425	29.0	0.233
Scotch	1,426	3.4	0.238
Croation	1,336	3.2	0.240
Welsh	476	1.2	0.252
Russian	4,304	11.0	0.256
Slavonian	13,376	35.6	0.266
Mexican	136	0.4	0.294
Austrian	6,229	20.4	0.328
Tyrolean	240	0.8	0.333
Rumanian	58	0.2	0.344
Finnish	159	0.6	0.377
Lithuanian	1,594	6.2	0.389
Spanish	195	1.4	0.718
Granish	216	2.0	0.926
Serbian	204	2.2	1.078
Norwegian	9	0.2	2.222
Others	5,511	3.2	0.058
Total	153,646	325.9	0.212

TIME OF DAY THAT ACCIDENTS OCCURRED

Figure 1 shows the time of day when accidents, excepting explosions, occurred during the 5-year period. It is noticeable that most of the accidents occurred during the forenoon, with the peak between 11 and 12 o'clock. There was a rapid decrease in the accidents between noon and 1 p.m., and a rapid increase up to 3 o'clock, after which the accidents occurred much less frequently. The peaks, of course, occur between 7 a.m. and 4 p.m., during which time the day shifts are in the mines. The high peaks occurring between 11 and 12 a.m. and between 2 and 3 p.m. are fatigue periods, and are also periods when employees are hurrying to complete particular jobs before lunch or to finish the day's work. The peaks here are due largely to falls of roof and coal accidents, a more detailed discussion of which is made later in this report. The rapid decline in the number of accidents occurring between noon and 1 p.m. may be accounted for by the fact that most of the underground and of the surface employees eat their lunch during this period.

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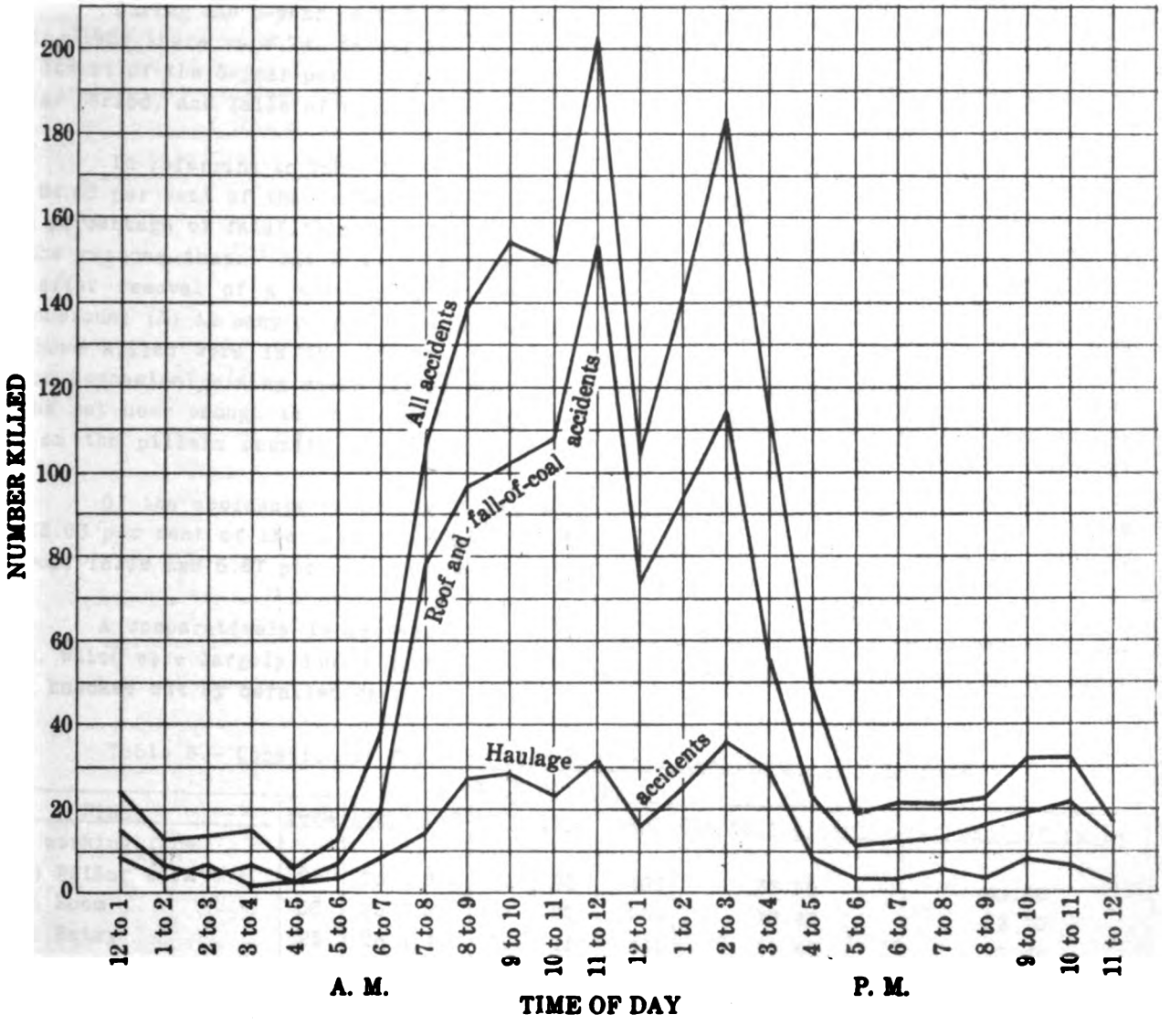

Figure 1.— Time of day when accidents occurred

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CAUSES OF ACCIDENTS OCCURRING DURING 1926 to 1930

Roof and Coal Fall Accidents

During the 5-year period covered by this study, falls of roof and coal were responsible for 53.08 per cent of all fatalities in Pennsylvania's bituminous-coal mines, which is about equal to that of fatalities from this cause in the United States as a whole.

During the 5-year period, fatalities from this cause have decreased to some extent. During 1926 there were 241 fatalities and during 1930 there were 200; the record for 1928, the lowest of the 5-year period, was 170 killed. Falls of roof caused 887 fatalities in the 5-year period, and falls of coal caused 165.

In referring to Table 5, it is seen that 45.66 per cent of the roof-fall accidents, and 64.85 per cent of the coal-fall accidents occurred at the face of pillar workings. The high percentage of fatalities occurring at the face of pillar workings may be accounted for by the reasons that: (1) A great percentage of the coal mined is from pillar workings; (2) after removal of a portion of the pillar, the roof usually settles, making it more treacherous; (3) in many places timbers must be removed to effect a roof breakline, and many of those killed were in the act of removing timbers when they were caught by the roof; (4) in mechanical mining where pillar coal is loaded by scrapers or conveyors, timbers can not be set near enough to the coal to support the roof properly; and, (5) settling of the roof on the pillars usually crushes and loosens the coal, which may fall without warning.

Of the accidents occurring at the working face, 23.10 per cent of the roof falls and 23.03 per cent of the coal falls occurred at room working faces, and 12.40 per cent of the roof falls and 6.67 per cent of the coal falls occurred at entry working faces.

A comparatively large number of roof-fall accidents occurred on roadways or entries, which were largely due to horsebacks or slips that were not perceptible, and to posts being knocked out by derailed cars.

Table 5.- Location of falls of roof and coal accidents, 1926 to 1930

Place	1926	1927	1928	1929	1930	Total	Per cent of total	Per cent of falls
FALLS OF ROOF								
1. At working face								
(a) Pillar work	89	73	68	92	83	405	38.50	45.66
(b) Room	56	55	34	33	27	205	19.49	23.10
(c) Entry	25	26	13	30	16	110	10.46	12.40
2. In room	18	11	6	8	14	57	5.42	6.42
3. On roadway or entry	20	21	18	23	22	104	9.89	11.72
4. On slope	4	2	-	-	-	6	0.57	0.70
Total	212	188	139	186	162	887	84.33	100.00
FALLS OF COAL								
1. At working face								
(a) Pillar work	16	17	23	29	22	107	10.17	64.85
(b) Room	10	10	5	5	8	38	3.61	23.03
(c) Entry	1	-	2	4	4	11	1.04	6.67
2. On roadway or entry	2	-	1	2	4	9	0.85	5.45
Total	29	27	31	40	38	165	15.67	100.00
Grand total	241	215	170	226	200	1,052	100.00	100.00

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Occupations of Those Killed by Roof and Coal Fall Accidents

Table 6 lists the occupations of those killed by roof and coal falls during the 5-year period, 1926 to 1930, inclusive. Of these occupations, most of those killed were employed as miners, mining machinemen, and timbermen. It is also noted that many drivers were killed during this period by falls, most of whom were killed when derailed cars knocked out props, allowing the roof to fall.

Of the miners killed, 61.66 per cent were machine miners, and 38.34 per cent were pick miners; the former represent 63.83 per cent and the latter represent 36.17 per cent of the average number of miners employed. From these figures it is seen that the pick miners, representing 36.17 per cent of all the miners, were responsible for 38.34 per cent of the fatalities from falls during the 5-year period. It would then appear that the hazard of falls in pick mining is slightly greater than where the coal is undercut by machines.

Table 6.- Occupations of those killed by roof and coal falls, 5-year period — 1926-1930

Occupation	Number killed
Machine miners	492
Pick miners	306
Mining machinemen	63
Timbermen	52
Drivers	25
Trackmen	20
Laborers	16
Rockmen	16
Brakemen	9
Shot firers	7
Assistant foremen	6
Motormen	5
Pillar foremen	5
Wiremen	5
Fire bosses	4
Bratticemen	3
Conveyor loaders	3
Pumpers	3
Masons	3
Mine foremen	2
Roadmen	2
Driller	1
Machinist	1
Rope rider	1
Door boy	1
Signalmen	1
Total	1,052

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Time of Occurrence of Roof and Coal Fall Accidents

Referring to Figure 1, it is noted that comparatively few falls of roof and coal accidents occur between the hours of 12 midnight and 6 a.m., but between 6 and 7 o'clock in the morning these accidents begin to increase and reach a peak between 11 a.m. and 12 o'clock noon, with a decided drop between 12 noon and 1 p.m., from which time accidents begin to increase, reaching another high peak between 2 and 3 o'clock in the afternoon.

The high peaks occurring between 11 a.m. and 12 noon and between 2 and 3 p.m. may partly be explained by the fact that during these periods (1) the maximum area of roof is left unsupported, (2) unsupported draw slate falls before the miner chooses to take it down or support it with timber, (3) the miner experiences the maximum fatigue, (4) the workman is hurrying to complete his work before the lunch hour and before leaving the mine at the end of the shift, and (5) these periods immediately follow shooting in many mines.

FACTORS INFLUENCING ROOF AND COAL FALL ACCIDENTS

During the study of the fatality records of the Pennsylvania Department of Mines for the 5-year period, 1926 to 1930, all those factors which appeared to have an influence or bearing on the accident were noted and tabulated. The State inspectors investigate each fatal accident and prepare a complete report on it: Table 7 was compiled from these reports.

Table 7.- Factors influencing roof and coal fall accidents

	Number	Per cent of Total
Failure to test roof	137	8.71
Insufficient or improper timbering	450	28.61
Supervision and discipline	291	18.50
Post knocked out by car	42	2.67
Removing post	84	5.34
Horsebacks, slips (not perceptible)	171	10.87
Mechanical loading	13	0.83
Taking down slate	57	3.62
Blast fired between time of official inspection and accident	288	18.31
Mining machines	40	2.54
Total	1,573	100.00

During the period covered by Table 7, 1,052 fatalities occurred from falls of roof and coal. It will be noted, however, that the total number of cases listed in this table is 1,573, which may be accounted for by the fact that several factors may have influenced a single accident; for instance, insufficient or improper timbering may be due to supervision and discipline.

Failure to Test Roof

In 137 cases, or 8.71 per cent of the total, the accident may have been prevented had the victim tested the roof properly.

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The general method of testing the roof is to "sound" it by striking it with a bar or pick.[3] The character of the sound is an approximate indication of the stability of the roof. If the sound is hollow or "drummy," the roof is probably loose and dangerous; it then should be taken down or supported with timbers. If a drummy sound is not noted this does not indicate that the roof is safe, for if a dangerous piece of roof is large it frequently does not give off hollow sounds which may be readily detected by the ear.

Inasmuch as the character of the roof can not always be determined by sounding, a more reliable method should be employed. The vibration method, which has been found to be more dependable than sounding and is readily applicable to coal beds less than 8 feet thick, consists of placing the bare fingers of one hand lightly against the roof, and with the free hand striking the roof sharply with an iron or steel bar. The degree of vibration of the roof against the fingers gives a fairly definite indication of the condition of the roof, provided that there is not too large a mass of loose material involved. When the roof is beyond the reach of the hand, a second rod may be held against the roof by the free hand while the roof is struck with a rod; and usually vibrations will be felt in the second rod if the roof is unsound or loose.

The vibration method of testing roof should be employed in addition to using sound indications, and rules should be adopted by all operating companies to provide that the roof and sides of working places shall be tested by the workmen when they go on shift, immediately after firing any shots, when a supervising official makes his visits, and at intervals not exceeding two hours during the shift.

The adoption of this rule, and its thorough enforcement, will be a large factor in preventing accidents from falls of roof and coal.

Insufficient or Improper Timbering

The greatest factor influencing roof and coal fall accidents evidently was failure to provide sufficient or proper timbering, since in about 28 per cent of the cases studied, the State inspector reported that the accidents might have been avoided if proper timbering had been employed. Many of these fatalities have occurred because the miner was unwilling to take the time to set supports or had delayed setting a post until he had performed some other task, and there is no question that in some cases the difficulty was due to lack of available timber.

So many fatalities occur from failure of one nature or another in connection with timbering that it is questionable whether it is in the interest of safety to rely wholly upon the miner to exercise his judgment as to the time and place of setting a prop, cross-bar, or other type of roof support.[4]

In many coal mines it has been found that little or no attention has been given to making or to following regulations for timbering; in others the matter has been fully considered.[5] Observations made at the latter mines have prompted the presentation of the following six essentials for mine-roof support in the interest of the former. In any scheme for protection against roof hazards there must be:

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3 Tomlinson, H , Reducing Accidents from Falls of Roof in Coal Mines. Part 3: I. C. 6225, Bureau of Mines, 1930, 11 pp

4 Paul, J. W., Stop, Look, and Listen! The Roof is Going to Fall: I. C. 6032, Bureau of Mines, 1927, 3 pp.

5 Paul, J. W., Six Essentials for Mine-Roof Support. Part 1: I. C. 6225, 1930, 11 pp.

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1. Some definite system for setting timber; such a system is in the interest of economy in operation and of safety to the workman.

2. The adoption of diagrams for the use of underground officials and miners, which is a great aid in promoting regularity in setting timbers.

3. A definite system of diagrams illustrating the manner of placing timber, as the instruction of miners by underground officials is more easily accomplished and uniform practice is made possible.

4. Rigid inspection and close supervision; these measures are most essential in establishing methods which have to do with support of mine roof.

5. A record kept as to the manner in which timber regulations are executed or neglected; the use of timber or other forms of roof support, if not properly set, may be the cause of roof failure.

6. A plan or a scheme for the accomplishment of a definite course of action; there can be little or no discipline without a plan, and to enforce discipline there must be some penalty for neglect to follow instructions as set forth in the plan or scheme - in this case, systematic timbering.

When a plan of action has been adopted for roof support as a means of protection against accidents from falls of roof, it is recommended that a trained and experienced section or face boss be employed for each section of the mine to observe the roof constantly, to persist in pointing out roof dangers, to the miner in his working place, to give instructions as to how to safeguard the men from the danger, and to see that his instructions are promptly carried out.

Supervision and Discipline

The second largest factor that influences roof and coal fall accidents as revealed by this study is that of supervision and discipline.

Investigations of mine accidents by engineers of the United States Bureau of Mines indicate that the reduction of accidents is, other factors being equal, in direct proportion to the efficiency of the supervision, and those companies which have the best records are in general those that hold their foremen responsible for the safety of the men working under them and have a sufficient number of overseeing officials to allow of giving efficient supervision.

Reckless men are a reflection on the effectiveness of the management; either they should have never been employed or they should have been discharged before serious accidents occurred.[6] Careless men are careless chiefly because they are improperly supervised. The records show that miners with years of experience had neglected to support the roof when there was timber near by, and in many instances when they had been directed by the foreman to place the timber before doing any other work.

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6 Miller, A. U., Safety as Affected by Supervision and Discipline: I. C. 6194, Bureau of Mines, 1929, 6 pages.

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The strict and impartial enforcement of rules by the foreman is absolutely essential, and one of the best methods to insure proper supervision and strict enforcement of rules is for the management to hold the foreman directly responsible for the men under his supervision, but not to overload any one foreman with so much work of various kinds that he would be unable to give sufficient time to supervisory work.

It is believed that as a rule there is less supervision and discipline in mining than in any other important industry. In mining, 25 to 150 or more men are usually placed under one supervisory official whose section is often so scattered that he has to travel several miles to make one round. If the maximum number of men under one foreman were limited so that he could visit each working place at intervals of not more than two hours, he would then be able to instruct the men properly and see that his instructions were carried out.

Blasts Fired Between Official Inspection and Accident

In 288 of the 1,052 fatal accidents from falls of roof and coal, shots had been fired between the time of an official inspection and the accident. This would indicate (1) that shots are fired during the shift, either by shot firer or miner; (2) carelessness of the miner in not testing roof; (3) carelessness of the miner in not removing or properly supporting loose roof.

As a rule, shooting of the coal loosens the roof to some extent; this is especially true of the Pittsburgh coal bed, which is overlain by a draw slate that eventually has to be removed.

After shooting, the area of unsupported roof is likely to be large because the freshly shot-down coal prevents the placing of adequate supports. When loose roof is found in such places it should be removed before an attempt is made to load out the coal.

Most of the fatalities from falls of roof or coal after shooting are in those mines where the miner does his own shooting. In mines where the shooting is done by a shot firer, the place is usually inspected by him after the blasts; and if a dangerous condition exists, the miner is instructed how to handle it or is aided in the handling of it.

Fatalities occurring from falls of roof or coal after shooting could be greatly reduced if a longer waiting period was allowed before the men returned to the working face, during which period the material loosened by the shot or shots would fall without doing any damage. In mines where the shooting is done by shot firers after all other men are out of the mine, fatalities that occur from falls after shooting is, of course, unknown; and there is no question that this is much safer than any method of blasting with the shift in the mine. The general practice in Pennsylvania is to do the shooting during the working shift; and it is believed that many fatal accidents could be avoided if those shooting the shots were required to wait at least 30 minutes before returning to the working face, thus giving ample time for the smoke to clear away and for the preliminary falls to occur.

Falls of "Horsebacks" or "Pots"

Falls of "horsebacks" or "pots" whose presence was reported as not being perceptible, were responsible for 171 fatalities during the 5-year period. Generally, concealed horsebacks or pots are not detectable by ordinary testing, and in most instances they fall

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without preliminary warning. Frequently, such accidents are classed as unavoidable because the pot or horseback that fell was not perceptible; but if systematic timbering is in effect and timbers set at certain fixed intervals, there is good reason to believe that many of this type of so-called unavoidable accidents would be avoided. On the other hand, it is generally the roof which appears to be good that falls and kills men; and here again, if systematic timbering were practiced, regardless of the apparent condition of the roof, a great many of these roof-fall accidents of all characters would be avoided.

Taking Down Slate

Fifty-seven of the fatalities due to falls of roof during the 5-year period occurred while the miner was taking down slate. Such accidents are frequently due to the carelessness of the victim in not properly protecting himself while performing this work, or in not using the proper tool. Pulling down loose slate or roof with a pick is dangerous work even though a man may be an experienced miner, and some accidents of this kind are more nearly unavoidable than almost any other kind of accidents which occur in mines. Long bars should be used for such work, and each miner should be instructed in the safe use thereof for releasing loose roof material.

Removing Post

There is little or no excuse for fatalities to occur from roof falls when posts are being removed; almost invariably the victim was either careless, lacked experience, or was not properly supervised. During the 5-year period covered by this study, 84 fatalities occurred by falls while posts were being removed. It is necessary in many cases to remove roof supports in pillar workings to effect a uniform break line or to secure effective caves or falls; such work should be done under the direct supervision of an official experienced in this kind of work. Posts or other timbers should not be knocked out with an ax or sledge, but post pullers should be used, with the operator standing well out of the danger zone.

Several fatal accidents occurred when posts were removed to make room for mining machines to operate along a face; when such procedure is necessary, safety posts should be set as near the face as possible before removing the post that is in the way of the machine. In some mines it is necessary to place a 3-piece timber set of two legs and a crossbar.

Post Knocked Out by Car

Most of the 42 men killed by falls when posts were knocked out by cars were haulage employees. Some of these fall accidents should rightfully be charged to haulage, as haulage equipment was directly responsible for them. The real remedy for prevention of fatalities from falls of roof caused knocking out of timbers by haulage equipment is the setting of timbers on haulage entries with legs of timber sets recessed into the rib, hence removed from effect of haulage wrecks or other haulage deficiencies. In a few cases, however, cars were pushed over the end of the track at working faces so that they knocked out posts; then the miner was responsible, as he should have provided blocks near the end of the rails.

Mining Machines

In 40 of the fatalities, mining machines were directly or indirectly responsible. In some of them it was necessary to remove posts to make room for the machine; in others

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the coal gave way after the cut was made, and caught the operators; and in some cases timbers could not be set in sufficient numbers because of the room necessary to manipulate the machine.

Special attention should be given by mining-machine operators to the removal of props near the face to make space for cutting machines. If it is necessary to remove a prop, the roof should first be carefully tested, and if found to be unsound, a collar or crossbar should be placed to span the place where the prop stood before its removal; and before leaving the place, the prop should be replaced and the collar or crossbar also left in place. If, in moving a machine, it should knock down a prop, the prop should be immediately reset.

Mechanical Loading

In 13 cases, mechanical loading was given as a factor in influencing the fall accident; in some instances, it was necessary to leave a large area of unsupported roof to make space for the machine; in others, the noise made by the machine did not give the operators an opportunity to hear the warning sounds given off by the loosened roof. The big factor in roof falls in connection with mechanical loading of coal is the space occupied by the machine which requires the leaving of a large area of unsupported roof.

During 1928 (the last year for which these figures are available) approximately 2 per cent of the coal produced in Pennsylvania was loaded mechanically by 1.6 per cent of those employed in loading coal.

In mechanical loading, new conditions arise in roof support.[7] Where scraper loaders are in use there is usually a large area of roof of considerable length and varying width where props can not be placed because they would be in the way of the scraper. In some places, timber or steel in the form of a cantilever should be used, and where there is danger of the roof breaking the props, consideration should be given to the use of cribs which may be moved forward as the face advances.[8]

Shaker conveyors, flight conveyors, and belt conveyors usually admit of systematic placing of timbers near the face of the coal before it is shot down.

Loading machines require a certain amount of clearance for their proper operation, and all loading machines should be used only where roof conditions permit the taking of the necessary precautions against roof hazards. An adequate number of timbermen of experience and discretion should be kept employed to test the roof and place timbers to insure protection against insecure roof wherever mechanized loading practice is in effect.

All men employed in mechanized loading should be instructed how to test the roof by the vibration method and be required to make the test at frequent intervals, because the sound method of testing is of essentially no value in the presence of the noise of machinery.

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7 Paul, J. M., What the Mine Foreman Can Do to Prevent Injury from Falls of Roof in Coal Mines: I. C. 6344, Bureau of Mines, 1930, 7 pp.

8 Harrington, D., Hazards in Connection with Concentrated Coal Mining: I. C. 6070, Bureau of Mines, May, 1928, 11 pp.

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Regulations for Preventing Roof-Fall Accidents

In the preceding discussion it has been pointed out that roof and coal falls are the most common and the most serious of the ordinary causes of mine accidents; more than half of the yearly accidental deaths in the coal mines of Pennsylvania are due to this cause.

The killing of approximately 200 bituminous coal miners every year in Pennsylvania by falls of roof and coal constitutes one of the greatest problems in the mining industry of the State; it means the loss of about one life every mine working day. These accidents happen to experienced as well as to inexperienced men, and this accentuates the fact that something is inherently wrong and that measures to lessen accidents from roof and coal falls which have been taken in the past unquestionably are inadequate. The substance of provisions that have been adopted by some companies that have been very successful in reducing falls of roof accidents is given here:

1. It shall be the duty of all company officials to exercise continuous, unremitting efforts to prevent the occurrence of accidents from falls of roof and coal.

2. The strict observance and enforcement of all rules, regulations, and laws shall be a condition of employment for all officials and employees.

3. Disregard of rules, regulations, and laws with respect to roof support shall be cause of dismissal of any official or employee.

4. The official in charge of any section of a mine shall be held personally accountable for workmen in his charge who disregard the regulations as to care of roof and timbering.

5. A foreman shall not be placed in charge of a greater number of working places or men than he can visit with sufficient frequency during a shift to insure observance of the regulations.

6. Strict adherence to a definite system of timbering shall be compulsory. Additional timbers, necessitated by special conditions, shall be placed immediately, as determined by the supervising official or the worker.

7. Upon finding any portion of the roof in need of immediate attention, the supervising official shall remain and see that any dangerous material is either taken down or properly supported; or he shall order the workmen to vacate the place at once and shall display a sign of danger at the approach to the place until such time as the roof is made safe.

8. The miners shall have suitable tools for setting timber. The company should supply mechanical post-pullers and an adequate amount of suitable timber reasonably close to the point where it must be used.

9. Each accident due to a fall of roof or coal shall be thoroughly investigated by a committee of underground officials, in which the official in charge of the district where the accident occurred is not included. The latter shall be permitted, however, to submit a statement to the committee. A copy of the report of the committee shall be placed on the bulletin board for the information and benefit of all underground workmen.

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10. In the interest of safety, miners should not be permitted to work alone. In general, two working places should be provided for each two miners, permitting them to work together in one place while the other is being cut.

HAULAGE ACCIDENTS

Haulage accidents caused 15.49 per cent of all fatalities during the 5-year period, which is nearly 20 per cent less than that for the United States as a whole. During 1930, there were 14 less fatalities from haulage than the average for the preceding four years.

Referring to Table 8, it is seen that the greatest cause of haulage accidents was getting caught between car or locomotive and rib. There are two principal reasons why such accidents occur, namely: (1) lack of clearance, and (2) derailed cars or motors due to defective track or equipment, or to defective practice or practices. The next greatest cause of haulage accidents was being run over by car or motor, which in many cases was due to the carelessness of the victim. The two causes - run over by car or locomotive and caught between car or locomotive and rib - are responsible for nearly 60 per cent of the haulage fatalities. Eighty-one per cent of the haulage accidents occurred in the haulageway, and 19 per cent occurred in working places.

Table 8.- Haulage accidents underground by causes, 1926-1930

Cause	1926	1927	1928	1929	1930	Total	Per cent
Switching and spragging	4	3	4	4	-	15	4.89
Coupling cars	-	-	-	1	3	4	1.30
Falling from trips	6	3	9	-	2	20	6.51
Run over by car or locomotive	14	19	15	23	7	78	25.41
Caught between car or locomotive and rib	21	23	24	19	19	106	34.53
Caught between car and roof	4	3	6	5	5	23	7.49
Runaway car or trip	5	7	7	7	11	37	12.05
Miscellaneous	11	5	2	3	3	24	7.82
Total	65	63	67	62	50	307	100.00

Occupation of Those Killed by Haulage Accidents

Those engaged in haulage are naturally more exposed to haulage hazards, and it would be expected that such employees would suffer a greater loss therefrom than those engaged in other occupations; however, experience in Pennsylvania during the 5-year period (refer to Table 9) shows that haulage employees suffered 43.32 per cent of the fatalities, while those engaged in other occupations suffered a loss of 56.68 per cent. Of those killed by haulage during the 5-year period, 40.39 per cent were employed as miners.

Of those employed in haulage, 1.07 per cent were killed in haulage accidents, while 0.135 per cent of those employed as miners were killed in haulage accidents.

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Tagle 9.- Occupations of those killed by underground haulage accidents, 1926 to 1930, inclusive

Occupation	Number killed					Total
	1926	1927	1928	1929	1930	
Haulage employees						
Motorman	8	8	8	5	8	37
Motorman's assistant	9	9	11	11	9	49
Driver	11	8	3	6	5	33
Car handlers	3	3	2	-	3	11
Rope rider	2	-	1	-	-	3
Total haulage employees						133
Machine miner	14	23	16	23	15	91
Pick miner	7	5	8	7	6	33
Trackman	2	-	4	2	-	8
Fire boss	1	2	2	1	-	6
Timberman	1	-	1	2	1	5
Machineman helper	-	1	2	1	-	4
Machineman	1	1	2	-	-	4
Laborer	1	1	2	-	-	4
Electrician	1	-	1	1	1	4
Machinist	2	1	-	1	1	5
Pumper	-	1	1	-	-	2
Roadman	1	-	1	-	-	2
Mine foreman	-	-	1	1	-	2
Driller	1	-	-	1	-	2
Rockman	-	-	1	-	-	1
Pipeman	-	-	-	-	1	1
Total	65	63	67	62	50	307

Time of Day of Haulage Accidents

Referring to Figure 1, it is seen that the trend of the time of day that haulage accidents occur follows closely that of all accidents and of roof and coal fall accidents, the high peaks occurring between 11 a.m. and 12 noon and between 2 and 3 p.m. It is difficult to explain the reason for the peak between 11 a.m. and 12 o'clock, but probably fatigue enters into it. The principal factor causing the high peak between 2 and 3 o'clock in the afternoon is probably that of haste on the part of haulage and other employees in their endeavor to clean up for the day.

Conclusions as to Haulage Accidents

This study of haulage accidents points to the irresponsibility of the employee and to the fact that a large responsibility falls upon the employer. The former factor is a human element that may appear difficult to control; however, it is within power of the employer to correct this condition by intelligent selection of employees and by following up such selection with just treatment and with rigid discipline.

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The prevention of haulage accidents depends largely upon proper equipment and proper maintenance of equipment, proper maintenance of haulageways, suitable layout of haulage for safe as well as efficient haulage of coal, and the adoption and enforcement of practices which will minimize haulage hazards, and one of these is care in the selection of the kind of men entrusted with haulage duties.

Fortunately, many accidents occur in haulage that do not result in injury to employees; such accidents almost invariably indicate that there were factors present which under similar circumstances might at another time contribute to the injury or death of an employee. All such accidents should be as carefully investigated as though they had resulted in an injury or a fatality, and the factors contributing to the accident should be corrected.

Haulage accidents generally entail greater economic loss than any other type of mine accident, excepting explosions and fires. As a rule there is an interruption of production; there is usually loss from damage to equipment; in some cases there is definite damage to the mine; and haulage accidents occasionally cause fires or explosions or both. The economic loss involved in haulage accidents should justify special effort on the part of the mine management to take all feasible precautions to prevent their occurrence.

As in all phases of accident prevention in mining, it is necessary to work out an adequate set of rules pertaining to safe and efficient transportation; and irrespective of the adequacy of the rules, results of the right nature will not be obtained unless the officials exercise strict discipline.

GAS AND COAL-DUST EXPLOSIONS

Pennsylvania's record with respect to gas and dust explosions was better during 1930 than for any year during three decades. No major explosions occurred during 1930, and only five persons were killed by explosions. The record of deaths from explosions was exceptionally high for 1928 due to one disaster in which 194 lives were lost. The decrease in number of lives lost due to explosions may be attributed to (1) more adequate ventilation of gassy mines; (2) the more widespread use of rock-dust, permissible electrical equipment, and closed lights; (3) the use of permissible explosives: and (4) the employment of State inspectors to examine underground electrical equipment. Most of the explosions in Pennsylvania bituminous coal mines in recent years have been caused by arcs from nonpermissible electrical equipment.

There is less excuse for the occurrence of mine explosions than for any other accidents in or around coal mines; if the known methods of the prevention of ignition, and propagation of gas and dust are employed, the chance of having explosions, or at least of having a widespread explosion, is so remote as to be almost non-existent.

ELECTRICAL ACCIDENTS

Electrical contact accidents were responsible for 50 deaths during the 5-year period, 1926 to 1930. Of these, 33 were caused by contact with trolley wires, 12 by contact with mining-machine feed wires, 1 by bar or tool striking the trolley wire, 1 by contact with mining machine, 1 by contact with haulage motor, and 2 were classed as miscellaneous.

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Naturally, one would expect that those men having greater exposure to electrical hazards would be the persons who would suffer greater loss therefrom; however, the experience in Pennsylvania during the past five years does not bear out this fact. Of the 50 killed by contact with electricity, 34 were miners, 4 were mining-machine operators, 3 mining-machine scrapers, 2 motormen, 2 drivers, 1 rockman, 1 a pumper, 1 a trackman, 1 a timberman, and 1 a laborer.

As contact with trolley wires was responsible for 68 per cent of the deaths due to electrical contact, it is apparent that more precautions should be taken to prevent such contact. Where trolley wires are less than 6½ feet above the rail, they should be adequately guarded at all points, not only where men are required to pass under them, but throughout every foot of their length. The cost of universal guarding of trolley or other bare power wires which are less than 6½ feet above the floor is undoubtedly less in the long run than is the cost of the accidents resulting from failure to so guard the wires.

MINING-MACHINE ACCIDENTS

During the 5-year period, 1926 to 1930, 37 deaths were caused by mining machines. This is in addition to those killed by contact with mining machines and feed wires, and those killed by explosions caused by arcs from mining machines. Unquestionably, some of the 37 deaths caused by mining machines were due to carelessness on the part of the victim or the machine operator, but many were due to hazards brought about by the use of the machine or of loading or conveying machines used in the same places.

Of those killed by mining machines, 18 were machinemen's helpers, 13 were machinemen, 5 were miners, and 1 was a brakeman. There was little excuse for the deaths of the five miners and the brakeman, because there was no occasion for their being in proximity to mining machines while in operation; however, the fact that the mining machines in general use are poorly guarded or not guarded at all throws much of the blame for some of the accidents upon the mine operator or upon the manufacturer of the machines.

Ten of those killed were run over by mining machines, 8 were caught between the mining machine and rib, and 5 were caught in the bits of the machine; probably all of these deaths could have been avoided had proper precautions been taken.

EXPLOSIVES ACCIDENTS

During the 5-year period of this study, explosives accidents were responsible for 42 deaths, or 2.12 per cent of all deaths in Pennsylvania bituminous coal mines. Of those killed by explosives, 38 were miners, 2 were rockmen, 1 was a foreman, and 1 a loader.

Fifty-four per cent of all the explosives accidents occurring during this 5-year period were due to permature shots and delayed shots. Most of these deaths were due to the practice of blasting during the working shift. Some of the deaths from premature shots resulted from attempts to save a few cents in fuse and a little time; however, most of the deaths from this cause occurred where electric detonators were used. To avoid the possibility of premature shots, the uninsulated ends of the detonator lead wires should be twisted together or short-circuited by means of a metal clip, which should be maintained until ready to connect to the firing cable. In electrical blasting, a permissible portable battery should be used with at least 100 feet of cable.

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Six men were killed by shots breaking through rib or pillar. Such accidents result from no warning, or lack of warning, from not guarding a place effectively, and from carelessness. These accidents illustrate lack of instruction or supervision and again are a direct result of blasting while the shift is working.

Probably most of these explosives accidents could have been avoided had qualified shot firers been employed. There are many advantages in the handling of all blasting operations by certified or qualified shot firers, who should examine the place for explosive gas and dangerous roof before and after shooting; if carefully chosen and supervised, they can see that the holes are properly placed, will use the proper amount of explosive, and will see that it is properly placed and tamped. They can be held responsivle for warning men in adjoining workings if blasting is done while men are in the mine, and in general can give a reasonable assurance that so dangerous a practice as blasting will always be done safely and efficiently.

SURFACE ACCIDENTS

During the past five years, 86 men were killed on the surface at bituminous coal mines in Pennsylvania, which was 4.34 per cent of all mine accidents occurring during this period. Fifty per cent of these surface accidents were caused by mine and railroad cars and locomotives, 15 per cent were caused by machiney, 12 per cent by electricity, and 25 per cent resulted from miscellaneous other causes, such as falls of men or material, or burns. Compared to the number employed, officials suffered a greater fatality rate than any of the other employees on the surface.

DEATH DUE TO NATURAL CAUSES

While deaths from "natural" causes are not considered mine accidents, it is interesting to note the number of such deaths occurring in the mines of Pennsylvania. During the 5-year period covered by this study, 77 men, or a yearly average of 15.4 died from natural causes; the average age was 47.4 years. In a majority of these cases the attending physician pronounced the cause of death to be heart trouble.

It is quite probable that the number of deaths from natural causes could be greatly reduced, or at least the span of life prolonged, if physical examinations were given to all applicants for work and reexamination of all employees required annually. These examinations should be complete and rigid, but they should not be used to discriminate in the selection of employees or to dismiss from service the less fit, but rather to acquaint employees with their physical condition, to give helpful advice, to give medical attention for any ailments discovered, and to try to allocate workers to activities within the scope of their physical ability.

RESPONSIBILITY FOR ACCIDENTS

Responsibility for fatal accidents is placed by the Pennsylvania Department of Mines in the report on each case; and during this study the responsibility for the accidents was noted, with the following result:

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Table 10.- Responsibility for accidents according to Pennsylvania Department of Mines

	Victims
Responsibility in ordinary accidents:	
Victim	473
Official and victim	328
Accidental	291
Unavoidable	192
Officials	157
Equipment	141
Others	29
Undetermined	8
Responsibility for explosions:	
Equipment	253
Official	78
Victim	2

From this tabulation it is seen that the victim was adjudged responsible for 29 per cent of the individual accidents, and the victim and official were responsigle for 20 per cent. Most of the accidents charged to the victim and to the victim and official were caused by roof and coal falls and by haulage, where the victim had failed to test the roof, failed to set proper timbers, or failed to obey instructions; the last was certainly the result of improper supervision by the official.

It is probable that very few if any of the victims were ignorant of the necessity of using precautions to avoid the accidents that befell them, and it is difficult to understand why so many underground workers will work under conditions they know to be dangerous. Unless workers are compelled to take precautions, they will frequently take chances, and the only real remedy for this problem is intelligent supervision and strict enforcement of discipline.

Many of the accidents classed as accidental were haulage accidents in which apparently no one was to blame, and some were electrical contact accidents in which the victim could not be held directly responsible because of carelessness of for othere reasons. It is probable, however, that most of the accidents could have been avoided had the necessary precautions been taken or if the proper safeguarding of equipment had been in effect.

The accidents classed as unavoidable are mostly roof-fall accidents where horsebacks, pots, or slips were present and were not perceptible; in general many accidents of this type may be avoided if systematic timbering rules are in effect and timbers set at predetermined intervals, whether or not the roof appears to need the setting of timber to support it.

The accidents charged to equipment were mostly from haulage in which defective equipment was involved. As the operator is responsible for the upkeep of haulage equipment, he would likewise be responsible for fatalities resulting from such defective equipment. Equipment is also charged with being responsible for 75 per cent of the deaths due to explosions; the equipment in most cases was nonpermissible electrical machines, the arcs from which ignited gas or dust and caused explosions.

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The question of placing responsibility for mine accidents is important in that it gives a basis upon which precautions may be taken to avoid similar accidents. However, regardless of responsibility for a fatal accident, the victim and the operator and the public all pay for it - the victim with his life and the loss of his earnings to his family, the operator by compensation and other costs, and the public in the increased cost of the coal it consumes as well as in numerous indirect costs due to the accident.

ECONOMIC LOSS OF ACCIDENTS

Frequently insufficient recognition is given to the economic or money loss involved in accidents by the company, by the industry, and by the public generally. If the same intelligent attention were given to accident prevention as is given to production and other phases of mining, the results would frequently mean the difference between profit and loss. It has been repeatedly demonstrated that the prevention of accidents pays big dividends in dollars and cents.

Statistics compiled by the Pennsylvania Bureau of Workmen's Compensation, for bituminous coal mining of the State, show that for the 5-year period, 1926 to 1930, there were 114,113 mine accidents (including all disabilities lasting two days or more), or that one man was injured for every 6.73 men employed.[9] (See Table 11.) The figures for 1930 show a decrease of 3,381 accidents reported over the average for the preceding four years.

Table 11.- Pennsylvania bituminous coal-mining accidents REPORTED to the Bureau of Wirkmen's Compensation[1]

Year	Total	Fatal	Nonfatal[2]
1926	24,677	443	24,234
1927	23,656	389	23,267
1928	22,123	543	22,580
1929	23,539	408	23,131
1930	20,118	337	19,781
Total ..	114,113	2,120	112,993

1 Data furnished by the Pennsylvania Bureau of Workmen's Compensation.
2 Includes all disagilities lasting two days or more.

Tagle 12 shows the total amount of compensation paid during the 5-year period to be $15,951,076; this is an average of $3,553 for each fatality, $1,322 for each permanent disability, and $85.67 for each temporary disability.

From Tables 11 and 12 it is seen that during the 5-year period there was a total of 114,113 fatal and nonfatal injury cases reported to the Bureau of Workmen's Compensation, while there was only a total of 65,872 cases in which awards of compensation were made. In other words, 48,241 cases were reported for which no compensation was awarded.

9 One authority shows this figure to be one man injured for every 3.36 men employed during the period 1925 to 1929.

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Table 12.- Number of compensable accident cases and amounts of compensation AWARDED in the Bituminous-Coal Mining Industry of Pennsylvania[1]

Year	Total	Fatal	Permanent disability	Temporary disability	Total	Amount of Compensation		
						Fatal	Permanent disability	Temporary disability
1926	12,702	435	521	11,746	$ 2,958,443	$1,417,868	$ 651,040	$ 889,535
1927	12,393	423	492	11,478	2,796,944	1,344,944	566,642	885,117
1928	13,216	480	509	12,227	3,614,400	1,822,893	724,271	1,067,236
1929	14,025	403	482	13,140	3,392,061	1,498,953	642,816	1,250,292
1930	13,536	337	504	12,695	3,189,228	1,299,128	731,766	1,158,334
Total	65,872	2,078	2,508	61,286	15,951,076	$7,383,786	$3,316,535	$5,250,514

1 Data furnished by the Bureau of Workmen's Compensation of Pennsylvania. Includes accidents in mines employing fewer than 10 persons.

According to these figures, the average compensation cost per ton of coal produced in Pennsylvania during the past five years was 0.023 cent. It has been estimated that the medical cost, the wage loss, and the indirect cost is four times the compensation cost, which would mean a loss, due to accidents, of 0.115 cent per ton of coal produced if both the compensation or direct cost and the various indirect costs were included, or a loss of nearly 15 million dollars yearly to the bituminous coal industry of the State.[10]

Attention is called to the discrepancy between the fatality figures of the Bureau of Workmen's Compensation and those of the State Department of Mines. Those of the former include fatalities that occurred in mines employing less than 10 men, mines that do not come under the regulation of the State Department of Mines, and, therefore, are not included in its fatalities.

The economic losses due to accidents are not all covered by those than can be figured in dollars and cents; there is yet the social and community loss which can not readily be reckoned in money. During the 5-year period, 1926 to 1930, 4,840 widows and orphans were left dependent in Pennsylvania by fatal mine accidents. Although these dependents received a certain amount of compensation, in most cases such compensation is not adequate to provide the necessities of life, and the community, county, or State must contribute to the upkeep of these unfortunates.

CONCLUSIONS

The conclusions are given under each cause of accident, but two general statements may be made:

10 In a paper presented to the 44th Annual Meeting of the Coal Mining Institute of America, December 10, 1930, Rush N. Hosler, superintendent, coal mine section, Pennsylvania Compensation Rating and Inspection Bureau, estimated the direct cost of accidents in Pennsylvania bituminous coal mines to be 0.036 cent per ton and a total cost of 20 million dollars per year.

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1. Although Pennsylvania's fatality record in its bituminous-coal mines has been consistently lower than that for the United States as a whole, there is still much room for improvement. This can come only through conscientious cooperation of the miner and the operator, the making of safety a condition of employment, strict observance of the State mining laws, and of up-to-date safety practices which are in advance of any laws.

2. The bituminous-coal mining industry is far behind other industries of the State in the promotion of safety; and the conditions in the coal industry are fast reaching the point where only those companies that eliminate unnecessary losses, such as the loss from accidents, will be able to survive under the intensive competition which now exists and which will probably become more rather than less intensive.

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